**Task Order No. 813**
**Contract No. PCE-I-00-96-00002-00**

# SYR DARYA BASIN WATER AND HYDROPOWER O&M FINANCING ANALYSIS

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December 1998

Prepared for

Central Asia Mission
U. S. Agency for International Development

Environmental Policy and Institutional Strengthening Indefinite Quantity Contract (EPIQ)
*Partners:* International Resources Group, Winrock International, and Harvard Institute for International Development

*Subcontractors:* PADCO; Management Systems International; and Development Alternatives, Inc.

*Collaborating Institutions:* Center for Naval Analysis Corporation; Conservation International; KBN Engineering and Applied Sciences, Inc.; Keller-Bliesner Engineering; Resource Management International, Inc.;
Tellus Institute; Urban Institute; and World Resources Institute.

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## PROJECT AUTHORITY AND PURPOSE

This project, Syr Darya Basin Water and Hydropower O&M Financing Analysis, is a component of the Environmental Policies and Institutions for Central Asia (EPIC) program of the U.S. Agency for International Development, Central Asian Republics (USAID/CAR). As part of that effort, assistance is being provided to the Interstate Fund for the Aral Sea (IFAS) through the Scientific Information Center of the Interstate Coordinating Water Commission (SIC-ICWC), the Syr Darya Basin Management Organization (BVO Syr Darya), the United Controlling Center of Energy Systems of Central Asia (UDC Energia), and the Kyrgyz Republic to analyze constraints to financing operation and maintenance (O&M) of international (transboundary) water and hydropower facilities in the Syr Darya Basin (1998 EPIC Workplan Task 2.1.2).

This effort is concerned with the O&M costs of the major transboundary facilities that either store water for and/or deliver water to the four parties to the Interstate Agreement. The original agreement was entered into in March of 1998 by Kazakhstan, Republic of Kyrgyzstan, and Uzbekistan.(8) The Republic of Tadjikistan became a party to the agreement in August of 1998. A background paper was prepared that identified potential constraints to the full implementation of the Interstate Agreement. (13) That paper identified five economic issues that are potential constraints to implementation of the Interstate Agreement.

1. Monetizing exchanges between parties;
2. developing economic mechanisms to guarantee compliance;
3. determining what, if any, cost sharing arrangements are appropriate for operation and maintenance of common hydro-technical structures;
4. understanding the potential implications of the proposed Energy and Water Consortium for Syr Darya hydro-technical investments; and
5. the expanded use of water pricing to generate revenues and create incentives for efficient allocation of water resources.

The purpose of this project is to devise a cost allocation method that could be used to aid in resolving identified economic issues. Additional issues for which cost allocation methods to support cost sharing could be useful are:

- Execution of an investment policy, targeted at the construction and reconstruction and modernization of operating capacities; and

- Attraction of investments for the development of water and energy potential in the region.

## TRANSBOUNDARY SYSTEM

The transboundary system consists of storage reservoirs and conveyances that serve more than one of the member republics. The storage reservoirs are Toktogul, Andijan,

Kayrakum, Charvak, and Chardara. The associated main transboundary canals and collectors that serve more than one of the member republics make up the transboundary conveyances.

Figure 1 presents a schematic diagram of the basin showing the five major reservoirs, active storage capacity, installed hydro-power capacity, and service areas. Even in this simplified diagram, the interdependence of the transbasin facilities is apparent. When one considers the numerous interconnecting conveyances, the additional cascade hydro-power plants, the diversion barrages, the numerous side tributaries, the approximately 100 small reservoirs on those tributaries, and the thousands of kilometers of canals that are not shown on this diagram, it is quite clear that the transbasin storage and conveyance system is the underlying framework on which a massive basin-wide water supply and delivery system rests.

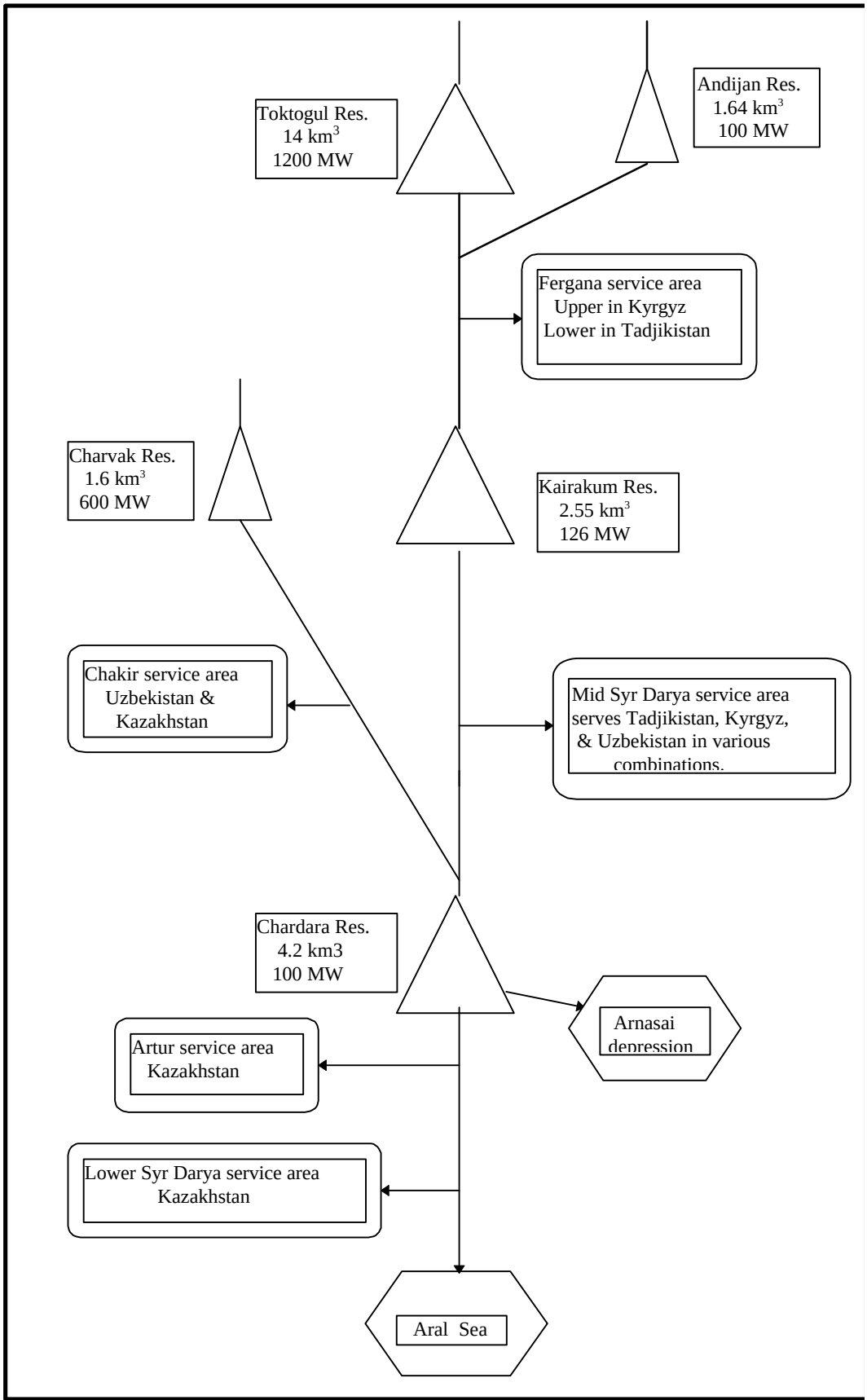


Figure 1. Schematic of Syr Darya Basin

Source of data: (5) Exhibit 6-1

## MANAGEMENT OF THE TRANSBOUNDARY SYSTEM

Management of the Naryn-Syr Darya transboundary system is conducted through the actions of the following organizations:

- Interstate Council of the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan and the Republic of Uzbekistan (ICKKTU)
- International Fund for Saving the Aral Sea (IFAS)
- Interstate Coordination Water Commission (ICWC)
- River Basin Management Authority (BVO Syr Darya)
- United Controlling Center of Energy Systems of Central Asia (UDC Energia)
- Scientific Information Center ICWC (SIC ICWC)
- Hydrotechnical Service, Kyrgyzenergoholding

ICKKTU (formerly ICKKU) was organized to facilitate implementation of the Treaty on Establishment of Economic Union and the Treaty on Creation of a Single Economic Zone and other interstate and intergovernment agreements. ICKKTU and its Executive Committee is the highest body dealing with international economic issues of mutual concern to the member republics. Its many responsibilities include implementation of concerted actions in important international sectors: transportation, communication, energy supply, environmental protection, and prevention and elimination of the consequences of emergency situations.

IFAS was established in 1994 by the Heads of Central Asian States for the purposes of coordinating financing of the Inter-regional programs in the Aral Sea Basin and managing contributions of donor countries, the World Bank, UNDP, and other international organizations. IFAS is guided by its Executive Committee which is approved by the Heads of the Central Asian States.

ICWC provides the institutional foundation for management of the transboundary system, formulates common water management policy, approves diversion limits and reservoir operational schedules, implements ecological programs , and coordinates major water activities. (6)

BVO Syr Darya is the executive interdepartmental body of ICWC. It provides observance of the schedule of flows and water consumption with due regard for water quality and flows to the Aral Sea. The BVO develops operational schedules for storage reservoirs, sets limits for each diversion works, estimates water shares for each state, and submits operational schedules of storage reservoirs to ICWC. (6)

UDC Energia schedules the day-to-day releases from Toktogul based on energy demand after BVO Syr Darya has determined the volumes to be released. (7)

SIC ICWC is the technical support group for ICWC. It provides the scientific foundations for dealing with water management problems, water resources management strategy, and long-term planning of transboundary water resources use in the basin.

The BVO and UDC-Energia are currently the executive bodies with responsibilities for release schedules and energy transfers. When and if the International Water and Energy Consortium and its executive body are established, those responsibilities could shift to the consortium.

The Hydrotechnical Service is the operational component of Kyrgyzenergoholding which manages all of the hydro facilities within the Kyrgyz Republic that has hydro-power generating capability.

## CURRENT O&M FUNDING

O&M for the transboundary facilities is funded through two sources. Those facilities that produce hydro-electric energy obtain O&M funding through the rate structure applied to energy sales. The rest of the transboundary system obtains O&M funding through contributions from the state budgets of the republics served. Neither source provides sufficient funding to meet the needs of ensuring long term sustainability of efficient system operation.

Water pricing is seen as a supplementary source for funding O&M. However, water pricing policies that have been adopted in each republic have not yet been fully institutionalized. Further more, when they are they will face the same problem of lack of ability to pay by the water users.

Sharing the costs between the republics based on a rational cost allocation is seen by some as a way of providing adequate levels of O&M. However, direct sharing O&M costs of the transboundary facilities is not generally acceptable to the republics. (12, p.3-7) That feeling is manifested in the English translation of Article VII of the Interstate Agreement which states: "The Parties agree that the operation, maintenance, and reconstruction of water and energy facilities shall be covered in accordance with the ownership of the property referred to in the balance sheet and the legal right of ownership." (8) That article is generally interpreted as requiring the republic in which the facility lies to finance and conduct O&M of those facilities. Presumably that interpretation is founded on the concern of each republic regarding protection of their sovereign rights.

In summary, inadequate funding from state budgets, reduced economic activity during the transition period from a command economy to a market driven one, general lack of ability to pay either taxes or water assessments, and unwillingness to share costs of transboundary facilities among the republics all contribute to the deficiency in funding of O&M of the transboundary system.

Since the each of the five transboundary reservoirs have energy generating facilities, current funding for O&M comes from the sale of energy. Therefore, republics pay in proportion to the energy they receive from the system. That method of cost allocation was arrived at through considerable negotiation and was formalized in the Interstate Agreement (8). It was proposed by the Kyrgyz Republic that a sharing of costs based on

proportionate sharing of water and energy be adopted. Kazakhstan and Uzbekistan representatives rejected that proposal and suggested that O&M costs for those facilities should be collected only through energy rates. There was some concern that basing the allocation of costs on water shares would in some way infringe on sovereignty rights.[1] The Kyrgyz representatives accepted that proposal under the condition that Kazakhstan and Uzbekistan would, in fact, purchase the excess energy generated during the growing season. That was acceptable to all parties and Article VII of the Interstate Agreement represents that condition.[2] However, that source does not generate enough revenue to provide the needed level of O&M.

A precise estimate of the needed level of funding for O&M of the five transboundary reservoirs and power plants has not been made, but a cursory estimate is that from 2 to 3 times the present level is needed to ensure long term sustainablility of services. That implies that the current level of O&M for these facilities is approximately 40% of what is needed. It is not felt that energy rates can be increased enough to make up that need.[3] That view was supported by discussions with the SIC-ICWC cost allocation study team.

Funding for O&M of the conveyance components of the transboundary facilities has progressively become more deficient over time. In 1994, O&M funding for the transboundary system started progressively decreasing. In 1997, the level of funding was only 37% of the needed level to sustain long-term system operational efficiency. That deficiency in funding has led to a deterioration of water management ability. Dukhovny stated that, "The process of decline in the management is seen everywhere, and in some places management has been totally lost, which is very dangerous for the future of irrigated agriculture and water management facilities." (21, p. 2) There is evidence that the decline in management capability is not a recent occurrence.

The State Expert Subcommision - Gosplan USSR reported in 1982 in reference to the Syr Darya Basin that, "The sharp deterioration of water management, ecological, and environmental conditions in the basin is largely a result of the fact that USSR Minvodhoz and Republic Minvodhozes, despite repetitious recommendation of the State Expert Commissions, do not pay due attention to the complex reconstruction of existing irrigation systems, development and extensive introduction of progressive methods of watering for the purpose of rational, and economic use of water, and control for the improvement of territories and quality of river water." (Reference 2, p. 15)

Funding for O&M of the water supply and delivery systems have traditionally come from the central government. The breakup of the Soviet Union has essentially set the central Asian republics adrift without funding from that traditional central source. Each republic must now provide the necessary financing. In order to do that, it must extract program

[1] The proposed agreement On the Principles of the Shared Recovery of Costs Associated with Operation and Maintenance of the Water Facilities of Interstate Joint Use, which is scheduled to be submitted to the Prime Ministers in January, provides for sharing costs based on water deliveries.(Reference 23)

[2] Interview of the Deputy Chairman, ICKKU.

[3] Interview of the Head of Hydro-Technical Services, Kyrgyz-Energo.

funds from the local economy through various forms of taxation and fees. However, the economic sectors, especially agriculture, are in a transition phase from centrally controlled to market driven economies that has left them in very weak financial conditions. The necessary markets, both for provision of inputs and sale and distribution of outputs, are still in embryonic stages of development. To summarize the situation briefly, the governments of the republics are unable to collect the necessary taxes to adequately support their programs, primarily because the economic sectors lack the ability to pay the taxes. That is particularly true for agriculture which, in large part, has been reduced to a barter system of exchange in both the input and output markets. (22)

There is one thing that is clear, even though the present method of allocating O&M costs of the transboundary system is acceptable to the republics, it is not meeting the financial need. There is a definite need to identify alternative methods of sharing costs in order to ensure adequate financing.

## CRITERIA for EQUITABLE COST SHARING

In this situation, the republics are intermediate water users served by the transboundary system. They pass the water on to the final water users within each republic. Sharing the O&M costs among the republics is the most likely way of providing adequate funding.[4] A sound theoretical rationale for sharing the costs of operating and maintaining the transboundary water supply and delivery system depends on the satisfaction of criteria for economic justification, economic efficiency, and economic equity. In addition, cost sharing must be acceptable to the respective republics.

### Economic Justification

Economic justification is deemed to be attained when economic benefits, to whom-so-ever they accrue, are greater than economic costs. That is normally determined by feasibility studies and confirmed by satisfaction of the standard criteria for justification which are; the benefit-cost ratio must be greater than 1, the net present value must be greater than zero, or the internal rate of return must be greater than the opportunity cost of capital. The "to whom-so-ever they accrue" phrase indicates this criterion is from a national perspective with no consideration of equity. In other words, it doesn't matter who receives the benefits as long as they materialize within the national economy. Also, it says nothing about who pays the costs. This criterion assures that there are enough benefits generated somewhere in the economy to cover the costs; however, it leaves open the possibility of the very inequitable situation where one group receives all of the benefits while another group incurs all of the costs. Therefore, economic justification is a necessary condition for devising an equitable cost sharing scheme, but it is not a sufficient condition.

[4] The degree to which O&M costs provided by the republics through their respective state budgets are recovered from water users is an internal matter within each republic that must be handled according to their respective water pricing policies.

## Economic Efficiency

Economic efficiency in the allocation of resources is defined as: An allocation of resources is efficient in economic terms if it is not possible to increase the welfare of one individual without decreasing the welfare of at least one other individual. This is a static equilibrium condition that in a dynamic economy is never attained, but a free market economy is always driven in that direction. Therefore, rather than dealing with a single static optimum, resource development deals with the comparison of at least two different allocations of resources. The question is whether a proposed reallocation of resources, such as a water supply system improvement, is preferred economically to the present allocation and that there is not an economically less costly way of accomplishing the same things. If so, it is more economically efficient than the present allocation and of any other alternative plans being considered for improvement. The economic efficiency criterion identifies that alternative that is the most economically efficient out of all of the alternatives being considered to accomplish the goals. This is usually accomplished during the plan formulation phase of feasibility studies.

The economic efficiency criterion begins to introduce a concern for equity that was missing in economic justification in the specification that the increase in welfare of one individual should not be at the expense of another. However, this still allows for the possibility that one group or individual could gain all of the benefit as long as no one else ended up with a loss. This is a movement in the right direction, but it is not sufficient to provide a foundation for a cost sharing scheme that allocates costs in proportion to benefits. In the view of those parties sharing costs but realizing no net gain, it would not be economically equitable and, therefore, likely not be acceptable to them even though it caused them no net burden.

## Economic Equity

The concept of economic equity is defined as a condition in which costs are commensurate with the benefits. That is, all beneficiaries share in the costs in proportion to the net benefits that they receive. This eliminates the possibility of one person or group realizing all of the gain or even a disproportionate share which was possible if only the economic justification and economic efficiency criteria were satisfied.

In summary, the satisfaction of the economic justification criterion assures that there are enough benefits generated somewhere in the economy to cover all of the costs. The economic efficiency criterion assures that, of the alternatives considered, the most economically efficient one will require the least expenditure of resources to attain the objectives. And, the economic equity criterion requires that costs will be allocated in proportion to benefits received. If these conditions are met, there should be little doubt about water users' willingness to pay their share of operations and maintenance costs on an average basis. This is a sound theoretical presumption, but it does not necessarily reflect the more practical view of water users. For any water pricing policy to succeed, it must be acceptable to the water users

### Acceptability

As stated above, if the economic justification, efficiency, and equity conditions are met, water users should be willing to pay fair assessments. However, water users generally do not know whether or not there is economic justification, efficiency, or equity. What they do know is what they observe, and what they observe is whether or not they receive an adequate water supply at the places where it is needed at the times it is needed. If they do not receive such supplies of water, they generally will not be willing to pay. In order for water users to view any water pricing policy as being acceptable, they must feel that they are receiving reliable service for the prices paid and that the prices paid are clearly understood to represent cost of services rendered. That is true whether the water user is a republic serving as an intermediate supplier or a direct water user such as an irrigator.

It is incumbent upon water supply managers to deliver water supplies, however limited, on a predictable and efficient basis. To do that, the water supply and delivery system must be in good operational condition. To ensure that the system in good operational condition, there must be an adequate level of funding for O&M of the system that is allocated equitably among the water users.

## ALTERNATIVE COST ALLOCATION METHODS CONSIDERED

The physical O&M of the transboundary facilities and the financial support of the O&M is the responsibility of the respective republics in which those facilities lie.(8, Article VII) However, since the transboundary system provides beneficial services to all of the basin republics, it would be more equitable if all benefiting republics share in the cost of O&M for those facilities and, in addition, it would more likely provide adequate funding, which is not being provided under the present financing methods. There are methods of cost allocation that yield results that should be viewed as equitable to all parties.

Three commonly used cost allocation methods are considered here. Those are the separable cost-remaining benefits method (SCRB), the alternative justifiable expenditure method (AJE), and the use-of-facilities (UoF) method. Which method is used depends on the data that is available since the methods have different data requirements. The SCRB method requires specific derivation of benefits for each function served. The AJE method is actually the SCRB method adjusted to account for the lack of ability to derive imputed separable costs. The UoF method rests on the assumption that the degree of use of the facilities provides a reasonable proxy for benefits received.

Before discussing the methods, perhaps it would be useful to briefly define some terms used in the allocation methods.

- Benefits: Quantifiable gains resulting from the use of the facilities.
- Investment costs: Cost of all inputs required to construct the facilities.
- O&M costs: Costs required to operate and maintain the facilities.

- Separable costs: The combination of specific single-purpose costs and imputed single-purpose costs.
- Specific single-purpose costs: The cost of a part of the facility that functions exclusively for a single service function, but is not an integral part of the common works of the facility, for example, a power plant that is specifically separable from the dam. Removal of that part of the facility would not impact the cost of or service from any other component of the facility.
- Imputed single-purpose costs: The cost of a feature that is an integral part of the common works. A hydropower penstock that is built into the dam is an example. It is integrated into the dam, but it serves only the power purpose. Such a cost can be separated from the dam, but in so doing, the cost of the dam itself would be changed. Such costs can be separated by comparing the cost of the dam without penstocks with the cost of the dam with penstocks. The difference in cost of the dam with penstocks and the dam without penstocks is the imputed separable cost that is assignable to the hydroenergy function. This requires a major effort in engineering design which is normally conducted during the planning stage prior to construction.
- Joint costs: The joint cost is the cost remaining after subtracting all separable costs from the total cost of the facility.
- Single-purpose alternative costs: The cost of the most likely alternative way of providing the same level of benefits of a single-purpose facility if the proposed (existing in this case) multipurpose facility were not built. An example would be the cost of the most likely way the same level of power benefits could be provided if the multipurpose facility being evaluated were not built. Clearly, the consideration of single-purpose alternates is best dealt with in an *a priori* planning setting where irreversible commitments have not already been made.

## Separable Cost-Remaining Benefit Method of Cost Allocation

The SCRB method is the most likely to yield more equitable results when used in a planning setting. However, it is the most demanding of data. Usually the heavy data demands are only met in an *a priori* planning setting, that is, during the planning stage before the facility has been built. Data requirements include total project costs, benefits provided by the project for each user group, single-purpose alternative costs, specific costs, imputed separable costs, and joint costs. The basic steps involved in applying the SCRB method are:

1. Derive the benefits for each purpose served by the facility (hydropower, irrigation, flood control, etc.).
2. Derive the alternative costs of single-purpose projects for each purpose served that would yield the same level of benefits as the multi-purpose facility would provide for each of those purposes.
3. Identify the specific costs.
4. Derive the imputed separable costs for each purpose which is the difference in project cost with and without each purpose.

5. Deduct the separable costs for each purpose from either the benefits or the alternative single-purpose costs associated with each purpose, whichever is less, to determine the remaining justifiable expenditure for each purpose.
6. Deduct the sum of all of the separable costs from the cost of the total facility to determine remaining joint costs.
7. Allocate the remaining joint costs to the purposes served in proportion to the remaining justifiable expenditures derived in step 4.
8. Sum the separable costs and allocated remaining joint costs to get the total allocated costs for each purpose served.

### Alternative Justifiable Expenditure Method of Cost Allocation

The AJE method, sometimes referred to as the adjusted separable cost-remaining benefit method, was developed for use in situations where derivation of the imputed separable costs is not feasible, but all other data requirements of the SCRB method are met. The steps are the same as the SCRB method without considering imputed separable costs.

1. Derive the benefits for each purpose served by the facility (hydropower, irrigation, flood control, etc.).
2. Derive the alternative costs of single-purpose projects for each purpose served that would yield the same level of benefits as the multi-purpose facility would provide for each of those purposes.
3. Identify the specific costs.
4. Deduct the specific costs for each purpose from either the benefits or the alternative single-purpose costs, whichever is less, to determine the remaining justifiable expenditure for each purpose.
5. Deduct the separable costs (sum of all specific and imputed separable costs) from the cost of the total facility to determine remaining joint costs.
6. Allocate the remaining joint costs to the purposes served in proportion to the remaining justifiable expenditures derived in step 4.
7. Sum the specific costs and allocated remaining joint costs to get the total allocated costs for each purpose served.

### Use of Facilities Method of Cost Allocation

The UoF method of cost allocation was developed to address the situation where project benefits for each function served are not available and the derivation of such benefits are beyond the scope of the allocation study. Also, it can be used in cases where derivations of separable costs and single-purpose alternative costs are beyond the scope of the cost allocation effort. The method rests on the assumption that the level of use of the facilities is an acceptable approximation of the benefits received. Physical relationships such as quantities of water delivered are commonly used as measurements of the level of use of facilities. The steps employed are:

1. Derive the level of use of joint project facilities for each purpose. Measures such as flow rates, water deliveries, reservoir capacity assigned to each purpose, and energy consumption are often used to represent the level of use by each purpose.
2. Identify the separable costs for each purpose.

3. Deduct all separable costs from the total project cost to determine the remaining joint cost.
4. Allocate remaining joint costs to each purpose served in proportion to the use-of-facilities factors developed in step 1.
5. Sum the separable and allocated remaining joint costs to get the total allocated costs for each purpose served.

## INTERNATIONAL COST ALLOCATION EXPERIENCES

Even though the SCRB method of cost allocation is the most thorough and is the most likely to satisfy all of the criteria for equitable cost sharing, it has heavy data requirements, much of which is available only during the planning and design stages of project implementation. Allocation of costs of facilities that have already been constructed where data required by the SCRB method are not available requires different approaches. That is the situation that is faced in allocating the O&M costs of the transboundary system. A brief look at some international experiences could help in selecting a cost allocation methodology to apply to the Syr Darya Basin.

The major facilities of the Nile River water supply system in Egypt has been developed over a period of approximately 100 years (some components are much older than that). In 1987 it was decided that an allocation of the costs of that system was needed. Both the UoF method and the SCRB method were used in allocating the costs of the Nile River water supply system. In 1987, Mohamed Allam used the UoF method in a landmark effort that was the first attempt to devise an allocation of the Nile River storage and distribution facilities.[5] Allam's rationale for selecting the UoF method over the SCRB method was because of its relative "…simplicity, theoretical soundness and economic attractiveness."

Another allocation of the Nile River system was conducted in 1993 by ISPAN, a consortium of firms under contract to USAID, using the separable cost-remaining benefit method.[6] ISPAN adopted the SCRB method over the UoF method because, as they stated, "... it avoids the possibility of violating the cost-sharing goals of equity and economic efficiency." Another reason given was that the SCRB method is recommended by the World Bank.[7] However, as was pointed out by Hutchens in a consultancy report for the International Irrigation Management Institute, ISPAN apparently failed to recognize the difference between the setting in which the World Bank endorsement of the SCRB method took place and the setting in Egypt.[8]

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[5] Allam, Mohamed Nasr, "Allocation Model for Irrigation Water Cost: Case Study of the Nile Valley in Egypt," *Water Resources Bulletin*, Vol. 23, No. 2, April 1987.
[6] ISPAN, "Irrigation Water Cost Recovery in Egypt: Determination of Water Costs," Virginia, USA, 1993.
[7] Gittinger, J.P., Economic Analysis of Agricultural Projects, 2nd ed., Johns Hopkins University Press, Baltimore, MD, USA, 1982.
[8] Hutchens, Adrian O., *Consultancy Report in support of Agricultural Cost Recovery Study No. 3: Strengthening Irrigation Management in Egypt*, International Irrigation Management Institute, Cairo, Egypt, March 1995.

The World Bank was addressing the allocation process from an *ex ante* planning setting where all actions being evaluated will occur in the future. As such, the single-purpose alternatives required by the SCRB allocation method represent opportunity costs that are real and impact meaningfully on decisions to be made. In that setting, all of the feasibility level engineering design data is readily available, irreversible commitments have not been made, and opting for the most preferred alternative is still open for taking. In Egypt, they were dealing with an *ex post* setting where the major decisions had been made and irreversible actions taken many years ago. That is a very important distinction. The consideration of alternatives to those irreversible actions would be highly speculative if not completely meaningless at this late date.

In an *ex ante* planning setting, it is true that the SCRB method will not violate the goals of economic efficiency and equity since water allocations are being determined through the planning process. However, in an *ex post* (after implementation) setting, water allocations have already been made. With a given allocation of water, any improvement in water-use efficiency would result in greater benefits and application of the SCRB method in *an ex post* setting would allocate more costs as a result. Therefore, in an *ex post* setting with specific allocations of water, the SCRB method will penalize water users for more efficient use of water, which can actually lead to a violation of the economic efficiency criterion. Also, in such a setting it is impractical, if not impossible, to derive reliable estimates of costs of a project with and without particular purposes being served, which is essential to deriving imputed separable costs. Also, deriving costs of single-purpose alternatives to the existing facilities is highly speculative. Therefore, the SCRB method is not well adaptable for use in *ex post* situations.

The cost allocation of the Syr Darya is in the same *ex post* setting. All facilities have already been built; therefore, the resources utilized in the construction of those facilities are irreversibly committed. The capital investment costs are not relevant to the allocation since they are "sunk", that is, there is no capital investment cost associated with these facilities that is under any obligation for repayment. Separable costs associated with single-purpose alternatives are not derivable. Benefit data are not available and it is beyond the scope of this study to derive the benefits.[9] Therefore, the UoF method of cost allocation is the preferred method of those considered for allocating the O&M costs of the transboundary facilities of the Syr Darya.[10]

[9] Plan of Action, Item No. 6, International Seminar of the Heads of the Ministries of Agriculture and Water Management and the Energy and Nature Protection Departments in the Central Asian Republics on the Rational Use of Water and Energy Resources in the Region, 20-25 July 1998, Issyk Kul, Kyrgyz Republic, calls for the development of computer models that could be useful in deriving benefit estimates. However, even if reliable benefit estimates are available, but water allocations are fixed, *ex post* allocations based on benefits can result in water users being penalized for more efficient use.

[10] Also the procedure for allocating costs specified in the draft agreement on the principles of the shared recovery of costs associated with O&M of interstate joint-use facilities is consistent with the UoF method.

MODEL for ALLOCATING O&M COSTS

The example cost allocation presented here is limited to allocating O&M costs because there are no outstanding capital recovery obligations for any of the transboundary facilities; therefore there is no capital cost associated with those facilities to allocate. Of course, future capital costs for new facilities or capital improvements to existing facilities should be allocated when those facilities are being considered for implementation. The model treats the transboundary facilities, which consists of the five storage reservoirs and the associated transboundary distribution conveyances, as an integrated whole.

In this model, releases are first allocated to energy and releases beyond the requirements for energy are allocated to irrigation. That is because it has been determined that during normal water years, the storage at Toktogul Reservoir, the center piece of the energy generating cascade, contributes essentially nothing to meeting the irrigation needs of Uzbekistan and Kazakhstan.[11] This allocation is based on normal water year conditions.

The model allocates O&M costs between energy and water supply in proportion to their shares of reservoir releases and then reallocates those costs to republics in proportion to energy and water deliveries.[12]

[11] Reference 4, page 4-1.

[12] The majority of water supply is for irrigation, but municipal and industrial consumptive uses are also included along with non-consumptive uses such as water transportation, fishery, recreation, and water quality improvement.

## Allocation to Purposes Served

There are two primary purposes being served, hydro-energy and water supply. The O&M costs to be allocated can be identified by netting out the separable costs for each function from the total O&M costs for the facilities. The remaining joint costs are the costs that must be allocated between the functions served. That process is represented by the following formula:

$$C_A = C_T - ( S_E + S_I ) \qquad \text{Equation (1)}$$

where $C_A$ = remaining joint O&M costs to be allocated
$C_T$ = total O&M costs
$S_E$ = O&M costs of the separable hydro-energy facilities
$S_I$ = O&M costs of the separable water supply facilities

### Allocation to Energy

The remaining joint costs are then allocated to the functions served in proportion to the water releases. The allocation of remaining joint costs to energy is depicted by equation 2. The releases for energy can be identified by the day-by-day releases called for by UDC Energia under the assumption that releases for specific purposes reflect the degree of use of the storage system for those purposes. (7, p. 14)

$$C_E = C_A ( R_E / R_T ) \qquad \text{Equation (2)}$$

where $C_E$ = allocated cost for energy,
$C_A$ = remaining joint O&M costs to be allocated,
$R_E$ = water releases for energy, and
$R_T$ = total water releases.

### Allocation to Water Supply

The allocation of remaining joint costs to water supply can be accomplished by equation 3.

$$C_I = C_A ( R_I / R_T ) \qquad \text{Equation (3)}$$

where $C_I$ = allocated cost for water supply,
$C_A$ = remaining joint O&M costs to be allocated,
$R_I$ = water releases for water supply, and
$R_T$ = total water releases.

However, since this model only allocates costs to energy and water supply, the allocation to water supply can also be determined by subtracting the joint O&M costs allocated to energy from the total joint O&M costs to be allocated. That can be done by using equation 4.

$$C_I = C_A - C_E \qquad \text{Equation (4)}$$

At this point, there is one more step to allocating O&M costs to the functions served. The separable costs that were netted out for each function in the beginning must now be added to the allocated joint costs to get the total allocated costs for each of the functions. That is done by equations 5 and 6.

Total allocation to energy: $C_{ET} = C_E + S_E$ Equation (5)

Total allocation to water supply: $C_{IT} = C_I + S_I$ Equation (6)

These costs must now be reallocated to the republics.

## Reallocation to Republics

Once the allocations to energy and water supply have been made based on water releases, the O&M costs that have been allocated to energy and water supply can then be reallocated to the republics based on deliveries of energy and water to each of the republics. The reallocation of the previously allocated water supply share of O&M costs to the republics could be made on the basis of historical shares of surface water resources. (3, p. 112)

### Reallocation of Energy Costs

This model allocates total O&M costs allocated to energy based on energy delivered to the respective republics based on the following assumptions:

- The transboundary energy facilities are operated as an integrated system.
- The energy produced is a non-differentiable product of that system.
- Therefore, costs will be allocated in proportion to the energy received by each republic.

Energy related O&M costs can be allocated to any specific republic by the following formula:

$C_{ES} = C_{ET} ( E_S / \sum_S E_S )$ S = the individual republics (states)

where $C_{ES}$ is the allocated O&M cost of energy to an individual state,
$C_{ET}$ is the total O&M cost allocated to energy,
$E_S$ is the total amount of energy delivered to that republic,
and $\sum_S E_S$ is the total amount of energy generated by the system.

An effective way of collecting the allocated O&M costs related to energy would be to incorporate those allocated costs into the pricing structure of energy. The costs would then be automatically collected through the sale of the energy.

Reallocation of Water Supply Costs

This model reallocates total O&M costs that have been pre-allocated to water supply based on water delivered to the respective republics. The reallocation rests on the following assumptions:

- The transboundary water supply facilities are operated as an integrated system.
- The water produced is a non-differentiable product of that system.
- Therefore, costs will be allocated in proportion to the water delivered to each republic.

Water supply is not broken down into its respective components in this model since that is a matter for each republic to deal with according to their own policies. For example, in Kazakhstan water supply consists of water for irrigation, industrial use, municipal use, fisheries, and water transportation. Water supply related O&M costs can be allocated to any specific republic by the following formula:

$C_{IS} = C_{IT} ( W_S / \sum_S W_S )$ S = the individual republics (states)

where $C_{IS}$ is the allocated O&M cost of water supply to an individual state,
$C_{IT}$ is the total O&M cost allocated to water supply,
$W_S$ is the total amount of water delivered to that republic,
and $\sum_S W_S$ is the total amount of water delivered to all of the republics by the system.

It should be noted that water that is released to non-productive side locations, such as Arnasai depression, and water that enters the Aral Sea are not included as water deliveries by this model, but costs associated with managing those waters are real, none-the-less. Since costs related to managing those waters are included in $C_{IT}$, any O&M costs associated with storing and conveying those waters are, in effect, automatically distributed to all of the republics in proportion to water deliveries and energy sales. The underlying logic of that is delivery of water to the Aral Sea is the joint responsibility of all of the republics. Water spilled to Arnasai is the collective result of management, or mismanagement, of the system which is also the joint responsibility of all of the republics.

EXAMPLE APPLICATION of MODEL

Sufficient data was not available for completing a cost allocation that represents actual conditions; therefore, to illustrate how the model functions an example allocation was fabricated. The results of this example do not represent the outcome that would be produced if actual cost, water release, and delivery data were used. This merely illustrates the process of conducting a cost allocation using this model.

Derivation of Transboundary Costs to be Allocated

The transboundary facilities consist of the five storage reservoirs and the transboundary conveyances. Complete cost data were not available for either. Therefore, for the sake of constructing the example, assumed costs were used.

Example Costs of Storage Reservoirs and Energy Facilities

Cost data were available for Toktogul, but not for the other four transboundary storage reservoirs. Therefore, the cost relationships for Toktogul were used to estimate the costs for Andijan, Charvak, Kayrakum, and Chardara merely for the sake of this example. The data for Toktogul are presented in Table 1.

Table 1: O&M Costs of Toktogul

| | Operation ($million) | Maintenance ($million) | Total O&M ($million) |
|---|---|---|---|
| Toktogul Dam & Reservoir | 2.72 | 1.03 | 3.75 |
| Separable hydro-power | 0.62 | 0.45 | 1.07 |
| Remaining joint costs | 2.10 | 0.58 | 2.68 |

Source: (7) Table 5-3

Given that the separable hydro-energy costs are specific to the energy generating facilities and the remaining joint costs relate to the reservoir we get the following relationships:

Separable energy cost per MW = ($1.07 x $10^6$)/(1200MW) = $900/MW

Reservoir costs per $km^3$ = ($2.68 x $10^6$)/(14$km^3$) = $190,000/$km^3$

Assuming those relationships hold for the other transboundary reservoirs, the following imputed costs result:

Andijan:
Separable energy facilities $900/MW x 100MW = $ 90,000
Reservoir costs 1.64 km3 x $190,000/$km^3$ = 310,000
Total O&M $ 400,000

Charvak:
Separable energy facilities $900/MW x 600MW = $540,000
Reservoir costs $190,000/$km^3$ x 1.6 $km^3$ = 304,000
Total O&M $844,000

Kayrakum:
Separable energy facilities $900/MW x 126MW = $113,000
Reservoir costs $190,000/$km^3$ x 2.55 $km^3$ = 304,000
Total O&M $597,000

Chardara:
Separable energy facilities $900/MW x 100MW = $ 90,000
Reservoir costs $190,000/$km^3$ x 4.2 $km^3$ = 798,000
Total O&M $888,000

Total O&M for transboundary storage and energy facilities

| | | |
|---|---|---|
| Separable energy | = | $1.9 million (rounded) |
| Reservoir costs | = | 4.6 million |
| Total | = | 6.5 million |

Example Costs for Transboundary Conveyances

No cost data was available for the transboundary conveyances and associated diversion control gates so, considering the extensive network of water involved it was assumed that the O&M cost for transboundary conveyances are 1.5 times the O&M cost for storage reservoirs. This results in a cost figure of $6.9 million ($4.6million x 1.5). Admittedly, there is no justification for this other than it provides a cost figure to be allocated in the example.

Example Cost Allocation

The example cost allocation was based on a set of assumptions regarding cost relationships. Those assumptions are:

- Under normal water year conditions, all water supply needs can be met without relying on storage from Toktogul. Therefore, in the example allocation all O&M costs for Toktogul are treated as separable to energy.

- It was assumed that the transboundary conveyances and associated headworks only provide water supply, they do not serve energy purposes. Therefore, O&M costs for these facilities are separable to serving the water supply purpose.

- Andijan, Charvak, Kayrakum, and Chardara are needed to meet water supply needs during normal water years. Since virtually all releases that are made are used jointly for both energy and water supply, instead of basing the allocation to purposes served on water releases, it was assumed that joint reservoir costs are distributed in proportion to the ratio of the separable power costs to the total.[13] For example, the joint costs allocated to energy for Andijan was derived as follows:

| | | | |
|---|---|---|---|
| Separable cost for energy | = | $ 90,000 | |
| Joint cost | = | 310,000 | The separable energy cost is 23% |
| Total | = | $ 400,000 | of the total. (90/400) |

Therefore, 23% of the joint cost was allocated to energy in addition to the separable cost.

[13] It could have been just as logically assumed that the ratio of separable costs to joint reservoir costs be used, which would have allocated a larger share of joint costs to energy.

Table 2: Transboundary Storage Costs to be Allocated

| | | ($ thousands) | Reservoir costs allocated to energy ($ millions) |
|---|---|---|---|
| Toktogul: | Energy facilities | 1070 | |
| | Reservoir | 2680 | All allocated to energy. |
| | Subtotal | 3750 | |
| Andijan: | Energy facilities | 90 | |
| | Reservoir | 310 | 23% allocated to energy = 0.1 |
| | Subtotal | 400 | |
| Kayrakum: | Energy facilities | 113 | |
| | Reservoir | 484 | 19% allocated to energy = 0.1 |
| | Subtotal | 597 | |
| Charvak: | Energy facilities | 540 | |
| | Reservoir | 304 | 64% allocated to energy = 0.2 |
| | Subtotal | 844 | |
| Chardara: | Energy facilities | 90 | |
| | Reservoir | 798 | 10% allocated to energy = 0.1 |
| | Subtotal | 888 | |

The entire estimated cost of $6.9 million was allocated to water supply based on the stated assumption that transboundary conveyances only serve water supply purposes, they do not serve energy purposes .

The resulting allocation to purposes served is presented in Table 3.

## Reallocation of O&M Costs to Republics

The O&M costs allocated to the purposes served were reallocated to the republics on the basis of service provided. For energy, the costs were assumed to be accurately reflected in the rates charged for energy. Therefore, the reallocation of allocated $5.1 million in energy costs to the republics would be automatically accounted for based on the energy deliveries to each republic.

There is no pricing structure for water supply comparable to that for energy. Therefore, the water supply service provided was presumed to be in proportion to the amount of water deliveries to each republic. The resulting allocation to purposes served is presented in Table 3.

Table 3: Allocation of O&M Costs to Purposes Served

| Description | Separable Costs ($ millions) | Joint Costs ($ millions) | Total Costs ($ millions) |
|---|---|---|---|
| Allocation to energy | | | |
| Toktogul | $ 3.8 | $ 0.0 | $ 3.8 |
| Andijan | 0.1 | 0.1 | 0.2 |
| Kayrakum | 0.1 | 0.1 | 0.2 |
| Charvak | 0.5 | 0.2 | 0.7 |
| Chardara | 0.1 | 0.1 | 0.2 |
| Conveyances | 0.0 | 0.0 | 0.0 |
| Subtotal | $ 4.6 | $ 0.5 | $ 5.1 |
| Allocation to water supply | | | |
| Toktogul | $ 0.0 | $ 0.0 | $ 0.0 |
| Andijan | 0.0 | 0.2 | 0.2 |
| Kayrakum | 0.0 | 0.4 | 0.4 |
| Charvak | 0.0 | 0.1 | 0.1 |
| Chardara | 0.0 | 0.7 | 0.7 |
| Conveyances | 6.9 | 0.0 | 6.9 |
| Subtotal | $ 6.9 | $ 1.4 | $ 8.3 |
| Total cost allocated to purposes | $ 11.5 | $ 1.9 | $ 13.4 |

Reallocation of Allocated Water Supply Costs

Historical water shares received by each republic in percentage of total supply are reported as follows: Kyrgyzstan 5.0%; Tadjikistan 7.5%; Uzbekistan 57.3%; and Kazakhstan 30.2%. (Reference 3, p. 112, Table 10.2) The reallocation to the republics of the $8.3 million of allocated water supply O&M costs, based on the distribution of water deliveries, is presented in Table 4.

Table 4: Reallocation of Water Supply Costs to the Republics

| Republics | % Distribution of Water Deliveries | Allocated Costs ($ millions) |
|---|---|---|
| Kyrgyz Republic | 5.0 | 0.42 |
| Tadjikistan | 7.5 | 0.62 |
| Uzbekistan | 57.3 | 4.76 |
| Kazakhstan | 30.2 | 2.51 |
| Total | 100.0 | $ 8.30 |

## STRATEGY for ADEQUATE O&M FUNDING

Maintaining national sovereignty is usually of major concern in transboundary water supply situations. Sovereignty can be protected by putting transboundary water management agreements on a government-to-government basis. In so doing, the respective republics become intermediary water suppliers. The republics are the direct recipients of the transboundary water which they, in turn, deliver to the final water users within each republic. Therefore, international financial obligations associated with the transboundary system should be met by the respective governments. That is, the funding for transboundary facilities should be paid entirely out of the respective state budgets. Specifically how that is to be done is negotiable, but an appropriate allocation of the costs can be useful in reaching an equitable cost-sharing agreement between the republics. The draft agreement on Principles of the Shared Recovery of Costs Associated with Operation and Maintenance of the Water Facilities of Interstate Joint Use has all of the essential elements of an equitable agreement. (23)

How the respective republics recover those costs from the water users in their republics is an internal matter subject to their own water pricing policies, but there are some aspects of effective water pricing that should be considered. It should be clear that any successful water pricing program should be aimed at legitimate, useful purposes. There is general agreement that the three primary purposes for water pricing are sustainability of services, water conservation, and mitigation of damages.

### Sustainability of Services

Each Republic has invested a tremendous amount of resources in developing the infrastructure that is referred to as the water economy. The purpose of that infrastructure is to provide water supplies to meet the many needs of society which includes potable water supplies for direct human consumption, appropriate water supplies to meet the needs of industry, and water supplies to meet society's need for food and fiber production, which is provided by agriculture. That infrastructure consists of water supply and delivery system facilities and the institutional organizations that must manage those facilities. It is absolutely essential that that infrastructure, both physical and institutional, be sustained at levels that ensure continued provision of those services in order to avoid severe hardships on society.

Sustainability of the water supply and delivery system to ensure continued provision of services is accomplished by generating enough funds to cover administration, operation, maintenance, and replacement of water supply and delivery system facilities. The source of such funds is not critical. They could come entirely from the state budget or entirely from the direct water users or some combination. However, if none comes from the direct water users there will be no incentive to conserve water and use it rationally.

### Conservation

If the water charges for sustainability of services are not sufficient to induce the desired level of water conservation, it will be necessary to impose an additional component of water pricing assigned specifically to the water users in order for them to feel the monetary impact of water use which will encourage them to practice the desired level of conservation. There is evidence of considerable waste of water in irrigation and it is quite possible that there are marginal lands being irrigated that should not be. Water pricing can be an effective instrument for encouraging efficient water use and for sorting out what lands warrant irrigation and what lands do not.

Mitigation of damages

The purpose of this component of water pricing is to provide funding to mitigate or off-set, at least in part, damages caused by the water use in question. This charge should be shared by all beneficiaries of the water-use causing the damage in proportion to the benefits received.

## CONCLUSIONS

A draft agreement has been prepared that defines the principles for sharing O&M costs of water facilities having interstate joint use. (23) That agreement on sharing the costs will be considered for approval at the Prime Minister level which will make it the direct responsibility of the signatory governments. Therefore, the initial funding should come entirely from the respective state budgets with each state government acting as in intermediary supplier of water to water users within their own republic. The degree to which those state-budget provided costs are recovered from the water users is an internal matter for each republic to deal with according to their own water pricing policies.

It does appear that each republic is now in the process of phasing in pricing policies to cover at least part of the cost of providing water supply and delivery services. However, to date during the transition to market economies, water users ability to pay is not sufficient to cover assessments, so the republics are phasing in water pricing policies over a few years. (12)

The draft agreement calls for cost sharing on operation, maintenance, capital repair and reconstruction of the facilities in proportion to the water received. The model for cost allocation presented herein should provide a useful tool with which to allocate those water supply related costs to the republics.

The current level of funding of O&M of the transboundary facilities is generally considered to be significantly less than required for sustainable effective operations although, as pointed out earlier, at least one high level official does not share that concern. Precisely what level of O&M funding is required is not well defined. There is a need for an on-site engineering assessment of the conditions of the facilities, the level of operation required to sustain effective service, and estimated cost of that level of operation. It is likely that implementation of the recommendations stemming from such an assessment would require financial assistance from international sources. Therefore, to ensure

objectivity, the team to conduct such an assessment should include international experts with experience in the operation and maintenance of major water supply and delivery systems and associated hydro-power facilities.

Resolution of the issue of adequacy of funding of O&M of the transboundary facilities and allocation of those costs to the republics depends on a reasonably accurate assessment of the condition of those facilities. Are they, in fact, in a severe state of deterioration? What is a reasonably reliable level of financing that is needed for the repairs necessary to bring the facilities to effective and efficient levels of performance? These are questions that must be answered before any responsible attempt at meeting the financial need can be made including allocation of O&M costs.

## RECOMMENDATIONS

- A team of highly qualified third-party engineering experts in O&M should be employed for the following purposes:
    1. Conduct an objective assessment of the condition of the transboundary facilities.
    2. Identify the level of financial effort required, if any, to bring those facilities to acceptable levels of operation.
    3. Delineate a level of continuing O&M activities necessary to ensure sustainablility of an acceptable level of operation.
    4. Specify the organizational structure, resources needed, and operating procedures for an entity to carry out those activities which should include a preventative maintenance program as well as operation and repairs.

- Conduct a seminar on cost allocation. Possibly one regional one with selected representatives from each republic attending or smaller separate ones in each republic. I do not have a good feeling for which would be better. Whatever venue is used, the attendees should have at least one hypothetical case study to assess.

- Support adoption of the draft agreement On the Principles of the Shared Recovery of Costs Associated with Operation and Maintenance of the Water Facilities of Interstate Use (reference 23 of the draft report)

- Support the implementation of the Council of Ministers Decision On International Consortiums which would institute a consortium with the responsibility and authority to comprehensively manage the transboundary facilities for the mutual benefit of all of the republics.

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